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Recovery of valuable metals from urban waste via oxidative dissolution in polyhalide ionic liquids

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PURPOSE OF THE ABSTRACT

Critical metals are considered essential for many high tech applications and to ensure a sustainable economy, however many of them suffer from a supply risk. To prevent resource depletion and to become independent of unstable exporting countries, it is crucial for regions like the EU to invest in the recovery of these critical metals from its own urban waste [1]. Since the key of recycling is dividing waste into fractions that can be reinserted in industrial processes, separating the metals present in alloys is crucial. These separation procedures however, require metal oxides or metal salts as starting products instead of metallic alloys, causing the need for an efficient oxidation process. However, the currently used processes suffer from several drawbacks. Hydrometallurgy uses mineral acids, creating large volumes of waste water and producing flammable hydrogen gas and the toxic NOx fumes (when using nitric acid) if metal alloys are dissolved in acids. Pyrometallurgical processes often use chlorine gas at high temperatures, which requires a lot of energy and involve large safety risks. A promising alternative is solvometallurgy and more specifically ionometallurgy, where ionic liquids (ILs) are being used in metallurgical processes instead of water as solvent. ILs are solvents that consist solely out of ions and have a low melting temperature (<100 °C). Their major advantages are: negligible vapor pressure, low flammability and a broad electrochemical window. When a polyhalide anion (e.g. triiodide) is part of the IL the term ?polyhalide ionic liquids? is applied. These can be easily made from trivial halide ILs by the addition of the appropriate halogen in a closed reaction vessel at room temperature. In contrast to halogens dissolved in organic solvents where both the halogen and solvent are volatile, polyhalide ILs can be considered as non-volatile halogen carriers that maintain the oxidative properties of the halogens [2]. Their negligible vapor pressure and strong oxidative power make them ideal solvents to oxidatively dissolve alloys into their respective halide salts [3]. With the added advantage that the entire dissolution process proceeds without the production of volatiles. The resulting solution, metal halides dissolved in the ionic liquid, is also feasible with many follow-up procedures such as solvent extraction or electrochemical manipulations in order to separate the metals or remove them from the IL. Afterwards the used IL can be recovered and again converted to a polyhalide IL, closing the cycle and eliminating large volumes of waste.

In this research, several critical metals, platinum-group metals and post-transition metals as well as alloys containing these metals were oxidatively dissolved in polyhalide ILs. The focus lies on metals used in applications with a high demand (magnets for electronic devices or electric motors and catalytic converters) or with an increasing importance in the future (LEDs). The metals were removed from the ionic liquid using electrodeposition or solvent extraction whenever it was possible. The ionic liquid was purified to the best extend and the regeneration of the ionic liquid for new dissolutions was investigated.

FIGURES

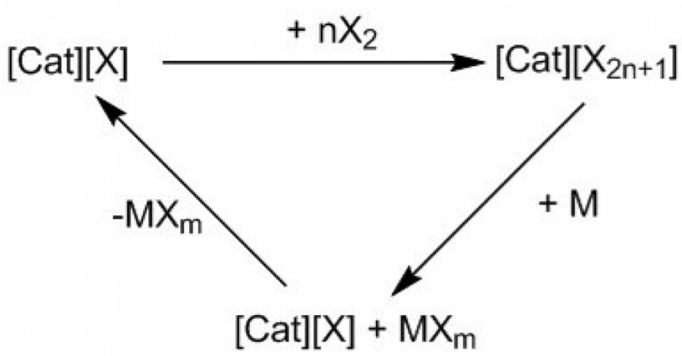

FIGURE 1

Oxidative dissolution and recovery of critical metals in polyhalide ionic liquids

Cat = IL cation

X = Cl, Br, I

M = Critical metals

FIGURE 2

KEYWORDS

Critical metals | Ionic liquids | Polyhalide | Recycling

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